Natural Resources Research, Vol. 27, No. 4, October 2018 (© 2018)
https://doi.org/10.1007/s11053-018-9371-x

Original Paper

Numerical Model of Two-Phase Flow in Dissolvable Porous Media and Simulation of Reservoir Acidizing

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Received 18 September 2017; accepted 27 January 2018
Published online: 8 February 2018

Mathematical model of porous media dissolution coupled with two-phase flow is proposed. The model is based on the conception of dissolvable porous medium with deformable mass-variable porous skeleton. Model can be used for simulation of coupled chemo- and hydro-geomechanical processes which are difficult to examine experimentally. Acidizing of calcite oil reservoir is used as an example of the process. Water solution of hydrochloric acid and oil are two fluid phases of the model with several components. Dissolvable porous media is treated as deformable mass-variable solid phase. Change in mass of the solid phase is caused by hydrochloric acid dissolving the calcite part of the solid phase. Dissolution is supposed to be congruent; kinetics is governed by the Nernst law. Software for numerical solution of the model is developed. It uses AmgCL parallel library for high-performance computing in order to deal with large algebraic systems on the each time step of calculations. The library uses algebraic multigrid methods for preconditioning and parallel iterative solvers. NVidia CUDA framework is used as a backend to perform GPGPU calculations, because it proved to be faster than OpenCL framework on this problem. Numerical experiments on the basis of data set from real reservoirs are conducted with the developed software. Good correlation between field and calculated data is achieved. Numerical experiments for different configurations of heterogeneous layer are performed. Acidizing of layers with highly permeable conduit and with random distribution of permeability is modeled.

KEY WORDS: Acidizing, dissolution, porous media, two-phase flow, mathematical model.

INTRODUCTION

Chemically active fluid flow in dissolvable porous media is a complex phenomenon that involves several coupled chemical and mechanical processes. Part of the solid skeleton of the porous media is dissolved during filtration. This leads to the considerable changes in properties of the media in the dissolution zone. These changes should be taken into account for the development of technologies that involve injection of solvents in porous media. Acidizing of near-wellbore area is an example of such technology. Exploitation of wellbores with time leads to layer degradation, decrease of permeability and thus lower values of oil production. These effects are particularly strong in low-permeable fractured layers when clogging of relatively small part of pores or fractures can dramatically change effective permeability of the layer and volume of oil production. Acidizing is used to deal with layer degradation. It involves injection of various acid agents into the layers in order to increase permeability of near-wellbore area and to improve the operational

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